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Imports Under a Foreign Exchange Constraint

Cristian Moran

To estimate how adjustment packages will affect the flow of imports, policymakers need to look beyond the traditional explanatory variables of gdp and real import prices. They must focus in addition on the availability of foreign exchange.

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The traditional model of import behavior—which looks only at gdp and real import prices as explanatory variables—failed to predict or explain the developing countries' import slumps in the early 1980s. It works well for industrial countries, unconstrained by foreign exchange. But it does not work well for the typical developing country, short of foreign exchange.

Hence, the search for a better model—a model more useful for developing country policy analysis. Hemphill introduced the availability of foreign exchange, measured by international reserves and foreign capital inflows, as a lone set of explanatory variables. This paper goes a step further and adds the traditional variables, prices and gdp, to international reserves and foreign capital inflows. The four variables together do a better job of predicting import responses—better than each of the two individually.

So, when putting an adjustment package in place, policymakers need to estimate how the availability of foreign exchange will affect the flow of imports. The focus is important because the policies that affect the availability of foreign exchange range more broadly than do policies affecting aggregate demand (contractionary fiscal and monetary policies and exchange rate policies). In addition to actions influencing aggregate demand and prices, the broader policies include those:

- To increase the export supply response.
- To keep international markets open to developing countries (that is, to reverse protection in industrial countries).
- To increase capital inflows, both official and private.

In sum: policy makers must look at the policies that affect gdp AND prices AND the availability of foreign exchange when trying to estimate import behavior in developing countries.

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IMPORTS UNDER A FOREIGN EXCHANGE CONSTRAINT (*)

Cristian Moran (**)

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IMPORTS UNDER A FOREIGN EXCHANGE CONSTRAINT

1. Introduction

The specification of trade models -- particularly of import models -- has generally been important in the analysis of policy packages to deal with macroeconomic imbalances. Such models have therefore received prominent attention in the economic literature (see Goldstein and Khan 1985, for a good survey of this literature). Although most earlier studies focused on industrial market economies, recent studies have concentrated on developing economies. But the traditional import model -- which links imports to domestic output and relative import prices -- has not proven useful in predicting the slump of LDC imports in recent years (Mirakhor and Montiel 1987). The most important reason for this failure is that this model neglects an important aspect of import behavior in developing countries -- the prevalence of foreign exchange constraints.

These foreign exchange constraints were tightened in the early 1980s, as drastic cutbacks in foreign lending, increases in interest rates, and declining commodity markets forced developing countries to make significant adjustments in their domestic economies. As a consequence, merchandise import volumes for all developing countries (excluding OPEC) remained stagnant during 1981-86, compared with increases of more than 6 percent a year during 1965-81. Countries in Sub-Saharan Africa and in Latin America -- unable to adjust rapidly to the new external circumstances and with a much higher level of external debt relative to their export earnings than other developing countries -- had a sharp reduction in imports. With low imports, investment deteriorated, and per capita output stagnated or declined.

Since these changes in the international environment have persisted, policymakers have struggled to devise packages that promote growth in developing countries without a significant deterioration in their trade balances. To analyze the choices available to them, policymakers and their advisers must be able to predict the response of imports to external and domestic shocks in the presence of foreign exchange constraints. Although different models have been proposed to analyze this problem, the approach suggested by Hemphill (1974) seems to be well grounded in the literature (see Chu, Hwa, and Krishnamurty 1983, Winters and Yu 1985, Winters 1987, and Sundararajan 1986). This paper expands Hemphill's approach by incorporating the traditional variables (relative prices and domestic income) with the variables introduced by Hemphill (foreign exchange receipts and international reserves). This expanded approach avoids the biases in the estimated import equations of previous studies -- biases due to the omission of relevant variables, or due to the simultaneity of import volumes and import prices.

Section 2 of this paper discusses the theoretical models developed in the present study. The traditional model -- used here as a benchmark -- is presented first, and is later extended to include foreign exchange constraints. Section 3 presents the empirical estimates of the general import models that include foreign exchange constraints, and two special cases -- the Hemphill and benchmark models -- using pooled, cross-section time series. Section 4 summarizes the main conclusions, and section 5 comments on areas of future research. An appendix gives a formal definition of the variables and describes the data sources.

2. Import Models

This section discusses the import models considered in this paper. It first presents a simple model used as a benchmark and discusses the assumptions on which it is based. It next considers an alternative model which explicitly incorporates foreign exchange constraints into the analysis of import behavior. Then it expands these approaches by allowing both the traditional variables (relative prices and domestic output) and foreign exchange constraints (proxied by foreign exchange inflows and international reserves) to play an active role in the determination of imports.

2.1 A Benchmark Model

Aggregate import demand equations can be specified in general terms in the following form:

$$m_t^d = g_t \; (PM_t, \; P_t^s, \; Y_t) \qquad (1)$$

where,

m_t^d = quantity of imports demanded at time t, obtained by deflating the nominal value of imports by an appropriate price index;

Y_t = scale or activity variable (nominal income);

PM_t = aggregate price (or unit value) index used to deflate the value of imports;

P_t^s = price of domestic substitutes;

and g_t is a function that links the independent variables (PM_t, P_t^s, and Y_t) to the dependent variable, m_t^d.

The following set of assumptions are normally used to make equation (1) estimable:

(a) g_t is independent of time, i.e. $g_t = g$ for all t;

(b) in addition to assumption (a), g is log-linear homogenous of degree 0 (the "no-money illusion" case) so that equation (1) can be written in the form:

$$\ln m_t^d = \alpha_0 + \alpha_1 \ln (PM_t/P_t^s) + \alpha_2 \ln y_t \qquad (2)$$

where $\alpha_1 \leq 0$, $\alpha_2 \geq 0$, and y_t is real income; 1/

(c) total imports -- as opposed to per capita imports -- are the appropriate dependent variable to use in the import equation;

(d) an aggregate domestic price index, such as the GDP deflator (P_t), can be used as the appropriate measure for the price of domestic substitutes;

(e) imports adjust with a lag to the desired quantities, following a simple "partial adjustment" mechanism:

$$\Delta \ln m_t = \theta (\ln m_t^d - \ln m_{t-1}) \qquad (3)$$

1/ Since imports are equal to domestic consumption minus domestic production, the theoretical income elasticity (α_2) can attain negative values. This would occur if domestic production is more income-elastic than domestic consumption (see Magee 1975, p. 189, for a formal statement of this condition). Empirical evidence for this possibility is scant, however.

where $0 \leq \theta \leq 1$ is a fixed adjustment coefficient (and hence the response of imports to a unit change in all the explanatory variables is presumed to be the same);

(f) foreign exchange constraints can be safely ignored in the estimation of import equations;

(g) the real price of imports is exogenous (or predetermined), so that each country faces an infinitely elastic import supply function.

Note that assumptions (a) through (g) imply that the import equation can be written in the form:

$$\ln m_t = a_0 + a_1 \ln (PM/P)_t + a_2 \ln y_t + a_3 \ln m_{t-1} + u_t \quad (4)$$

where a_1 ($= \theta\ \alpha_1$) and a_2 ($= \theta\ \alpha_2$) are now the short-term price and income elasticities, respectively. Since $a_3 = 1 - \theta$, the long-term elasticities are:

$$\varepsilon_p^{LT} = \alpha_1 = a_1/(1-a_3); \ \varepsilon_y^{LT} = \alpha_2 = a_2/(1-a_3).$$

Equation (4) constitutes the benchmark model.

In a previous paper I examined in detail the first four assumptions (a through d) normally adopted in the specification of import models (Moran 1987). That paper developed alternative models that allowed testing of: (i) the stability of the import function across time periods; (ii) the price homogeneity hypothesis; (iii) the use of per capita imports as the relevant dependent variable;(iv) the use of tradable and home goods prices as the appropriate deflators in the definition of the real import price. The paper also presented tests for the significance of the lagged dependent variable (assumption e). The main conclusion obtained from these tests was that the simple benchmark model performs generally as well as these alternative specifications, although occasionally these alternative models may better fit the actual import behavior of particular countries or time periods. I now concentrate attention on the last two assumptions, (f) and (g).

2.2 The Hemphill Model

This section introduces explicitly foreign exchange constraints to the analysis of import behavior. It adopts for this purpose the framework initially proposed by Hemphill (1974) and later extended by Winters and Yu (1985). Hemphill derives imports from an explicit optimization problem, assuming that the economic authorities in each country minimize the cost of adjustment to the long-run import level, m_t^* (equal, in stationary equilibrium, to the long-run level of foreign exchange receipts, f_t^*) by using reserves to smooth imports. He considers explicitly a quadratic cost function of the following form: 2/

$$C_t = \beta_1 (m_t - m_t^*)^2 + \beta_2 (r_t - r_t^*)^2 + \beta_3 (m_t - m_{t-1})^2 \qquad (5)$$

2/ Although Hemphill was mostly concerned with nominal imports (probably because international inflation was not important during the period he analyzed), the only concern here is with real imports, and all nominal variables have therefore been deflated by the import price.

where r_t is the level of real international reserves at time t; and r_t^* is the long-run desired level of international reserves, which he links to the long-run desired import level,

$$r_t^* = \gamma_0 + \gamma_1 m_t^*, \qquad \gamma_1 \geq 0. \tag{6}$$

To close the model, two additional equations need to be added. The first is the balance of payments identity,

$$\Delta r_t = f_t - m_t \tag{7}$$

where f_t is the real level of foreign exchange receipts at time t and includes both export earnings and autonomous capital inflows. f_t is assumed to be a predetermined variable in the estimation of the import equation.

The second equation needed to close the model makes an assumption about f_t^*. I adopted, initially, Hemphill's equation:

$$f_t^* = f_t + \lambda\Delta f_t = (1+\lambda)f_t - \lambda f_{t-1} \tag{8}$$

where λ indicates how changes in foreign exchange receipts are perceived. If λ is positive, the changes are perceived to be permanent and are extrapolated. If λ is negative, the changes are perceived to be transitory, and they are discounted. In the empirical estimation, however, it was found that λ could not be properly identified. To simplify the presentation that follows, therefore, I take $\lambda = 0$. 3/

The import equation can now be derived by minimizing equation (5), subject to the budget constraint (7), to obtain:

$$m_t = b_0 + b_1 f_t + b_2 r_{t-1} + b_3 m_{t-1} \tag{9}$$

where $b_1 = \beta_1' + \beta_2' (1-\gamma_1)$; $b_2 = \beta_2'$; $b_3 = \beta_3'$, $\beta_i' = \beta_i/\Sigma\beta_i$, and $\Sigma\beta_i' = 1$.

Equation (9) constitutes the Hemphill model. Note, in particular, that it excludes relative prices and domestic income. Hemphill justified this omission by arguing that developing countries will generally exhibit excess demand for foreign exchange -- and that measured import prices (estimated mostly with foreign suppliers data) will not reflect the true scarcity price of foreign exchange. Once a model is developed to capture these constraints explicitly, as in (9), there is no additional role for income and relative prices in that equation -- introducing them would amount to double counting. Note that this reasoning implies that changes in the real exchange rate or cyclical variations in income do not affect imports directly, but do so only through their effect on foreign exchange earnings. This assumption has been relaxed by subsequent writers (see, for example, Chu, Hwa, and Krishnamurty 1983 and Sundararajan 1986) and is certainly subject to empirical testing.

3/ That is, I take as a proxy for the long run level of foreign exchange receipts the current level of foreign exchange receipts. This is exactly the assumption adopted by Sundararajan (1986).

2.3 A General Import Model with Exogenous Prices

To see how relative prices and income could influence imports, consider a generalization of the Hemphill model -- still taking real import prices as exogenous to the import decision. Assume, as before, that the costs of adjustment to the long-run desired import level continue to be the primary motivation behind the determination of imports. But add one additional consideration to this decision: the cost of being off the country's notional import demand curve. This consideration can be included by adding one element to the cost function (5):

$$C_t = \beta_1(m_t - m_t^*)^2 + \beta_2(r_t - r_t^*)^2 + \beta_3(m_t - m_{t-1})^2 + \beta_4(m_t - m_t^d)^2 \qquad (5')$$

where m_t^d is the traditional import demand curve of the form considered in equation (2). Writing this equation in linear form (rather than log-linear) and minimizing equation (5') subject to the budget constraint (7) gives the following import function:

$$m_t = b_0 + b_1 f_t + b_2 r_{t-1} + b_3 m_{t-1} + b_4 (PM/P)_t + b_5 y_t \qquad (10)$$

where $b_1 = \beta_1' + \beta_2' (1-\gamma_1)$; $b_2 = \beta_2'$; $b_3 = \beta_3'$; $b_4 = \beta_4' \alpha_1$; $b_5 = \beta_4' \alpha_2$, $\beta_i' = \beta_i/\Sigma\beta_i$, $\Sigma\beta_i' = 1$, and α_1 is the change in the demand for imports due to a unit change in relative prices, and α_2 the change in the demand for imports due to a unit change in income. 4/

Instead of considering equation (10) directly, consider it in log-linear form,

$$\ln m_t = b_0 + b_1 \ln f_t + b_2 \ln r_{t-1} + b_3 \ln m_{t-1} +$$

$$b_4 \ln (PM/P)_t + b_5 \ln y_t + v_t' \qquad (11)$$

where v_t' is a normally distributed random error. This specification seems justified for three main reasons:

1. Previous empirical studies found the log-linear specification to be appropriate in traditional import equations (see Khan and Ross 1977 and Thursby and Thursby 1984).
2. The log specification greatly simplifies the interpretation of the estimated coefficients -- as they now represent elasticities.
3. The models considered previously become special cases of (that is, nested within) the more general equation (11). 5/

4/ Note that if $0 \leq \gamma_1 \leq 1$, as is assumed here, all the parameters of equation (14) can be signed unambiguously: $b_1 \geq 0$, $0 \leq b_2$, $b_3 \leq 1$, $b_4 \leq 0$, $b_5 \geq 0$.

5/ Note that we could have written the cost equation (5), the reserve equation (6), and the import demand curve in log linear form directly, but the balance of payments identity still needs to be written in linear form. This implies that the same procedure used to derive equation (11) will now yield an import equation which is not linear in the variables (or in the logs of the variables).

Equation (11) is the general import model with exogenous prices. The Hemphill model is then a special case, obtained by making $b_4 = b_5 = 0$ (or alternatively, $\beta_4 = 0$). The benchmark model can also be obtained as a special case, by making $b_1 = b_2 = 0$ (or $\beta_1 = \beta_2 = 0$).

Note that the structural parameters of the general import model presented here are not uniquely identified. Apart from the constant terms, there are seven structural parameters -- β_j, $(j=1,\ldots 4)$, γ_1, α_1, α_2 -- although only six of them are linearly independent, and five reduced form coefficients: b_i $(i=1,\ldots 5)$. Thus, even though the reduced form equation (11) can be easily estimated by traditional methods, there is no way of getting unconditional estimates of the structural parameters. This is not a serious problem, particularly if the interest is in the response of imports to a unit change in prices or income, after due account is taken of the foreign exchange constraint (since in this case the reduced form multipliers, b_i, are the relevant elasticities). Moreover, it is also possible to fix one of the structural coefficients and then obtain estimates of the remaining structural parameters conditional on that coefficient. I have not pursued this procedure here, however. Instead, I consider an alternative specification that explicitly introduces foreign exchange constraints, but allows recovering the structural parameters of the model.

2.4 A General Import Model with Endogenous Prices

Consider a different version of the general model where real import prices are endogenous to the import decision, thus relaxing assumption (g).

In this model, the Hemphill equation determines import supply, an assumption that seems particularly appropriate when the foreign exchange constraint is binding. Import volumes in period t are therefore determined by current foreign exchange receipts, by the stock of international reserves at the end of t-1, and by lagged imports (as adjustment costs are also taken into account). Import prices and aggregate output do not influence import volumes, but they do affect import behavior, as they constrain the demand for imports. 6/

The complete import model now contains two independent structural equations: an infinitely inelastic import-supply curve, and a normal downward-sloping demand curve;

$$\ln m_t^s = b_0 + b_1 \ln f_t + b_2 \ln r_{t-1} + b_3 \ln m_{t-1} + v_t \qquad (9a)$$

$$\ln m_t^d = a_0 + a_1 \ln (PM/P)_t + a_2 \ln y_t + a_3 \ln m_{t-1} + u_t \qquad (4)$$

where $m_t^s = m_t^d = m_t$ in equilibrium, and $(PM/P)_t$ and m_t are the endogenous variables. The supply and demand shocks, v_t and u_t, are assumed to be independent and normally distributed random variables, but may be contemporaneously correlated.

Two remarks need to be made. First, note that in this version of the model all structural parameters $(a_i, b_i; i = 1, 2, 3)$ are identified, and can be easily estimated. The import supply equation (9a), in particular, can be directly estimated by Ordinary Least

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6/ See section 5 for a natural extension of the Hemphill model where aggregate output influences import volumes.

Squares, to yield consistent and asymptotically efficient estimates. The import demand equation (4), however, cannot be estimated by OLS, as this would yield biased and inconsistent estimates of the relevant elasticities -- since $(PM/P)_t$ is endogenous, and hence correlated with the demand shock, u_t. Consistent estimates of the demand elasticities can, however, be obtained by using a simultaneous equation procedure, such as Two-Stage Least Squares.

Second, note that under the added assumption that the import supply and demand shocks are uncorrelated ($Eu_tv_t = 0$), the system formed by equations (9a) and (4) becomes recursive. In this case, the demand curve can be renormalized to express $(PM/P)_t$ as a function of m_t, and the resulting equation estimated by Ordinary Least Squares:

$$\ln (PM/P)_t = a_0' + a_1' \ln m_t + a_2' \ln y_t + a_3' \ln m_{t-1} + u_t' \qquad (4a)$$

This procedure would then yield consistent and asymptotically efficient estimates of a_1 $(= 1/a_1')$ and a_2 $(= -a_2'/a_1')$, respectively. 7/

Before turning to the estimation of these models, I present below another rationalization of equation (11). Consider again the traditional import demand equation (4), but ignore price homogeneity (this version of the traditional import model is used here to simplify

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7/ See Thurman (1986) for a discussion of this procedure. Note also that this procedure is justified only under the implicit assumption that equations (9a) and (4) constitute a recursive model. If one is unsure about the "true" structure, however, Thurman suggests running both price-dependent and quantity-dependent equations by OLS and Instrumental Variables, and testing for the bias implicit in the OLS estimates (using the Wu-Hausman test). The "adequate" structure would then depend on the results of this test.

the presentation that follows, but it changes nothing of substance):

$$\ln m_t = a_o' + a_1' \ln PM_t + a_2' \ln y_t + a_3' \ln m_{t-1} + a_4' \ln P_t + u_t' \qquad (4.1)$$

where all the variables have already been defined. Import prices can now be decomposed into a component reflecting the value of imports at border prices (PM_t^*), and another component reflecting domestic import distortions (Z_t), such as tariffs and non-tariff barriers:

$$\ln PM = \ln PM_t^* + Z_t \qquad (4.2)$$

where $Z_t = \ln (1 + t_{1t})$, and t_{1t} is the tariff equivalent of all tariff and non-tariff barriers at time t. Assume now that the variable Z_t is negatively correlated with foreign exchange inflows and international reserves (i.e., assume that domestic distortions are increased in response to a tightening of the foreign exchange constraint), and write this equation in log linear form:

$$Z_t = c_0 + c_1 \ln f_t + c_2 \ln r_{t-1} + w_t; \; c_1 \leq 0, \; c_2 \leq 0. \qquad (4.3)$$

Then, the import model with exogenous prices, equation (11), can readily be obtained by substituting equations (4.2) and (4.3) into equation (4.1) -- with an obvious identification of parameters.

Note that while this rationalization of equation (11) is certainly appealing, it invalidates the use of the import model with endogenous prices, equations (9a) and (4). This occurs because the instruments available for the estimation of the import demand equation (4) -- f_t and r_{t-1} -- are now correlated with the "true" error term of equation (4):

$$u_t = u_t' + a_1' w_t + c_1' \ln f_t + c_2' \ln r_{t-1}; \text{ where } c_i' = c_i\, a_1', \quad i=1,2$$

and hence their use will yield biased estimates of the parameters of that equation. The use of the model composed by equations (9a) and (4), however, can still be justified in either one of the following two cases: (i) domestic distortions are pervasive, but are mostly explained by non-economic factors (e.g., the desire to follow an import substitution strategy to foster industrialization), yet foreign exchange constraints are still an important element of import determination 8/; (ii) domestic distortions are insignificant, yet foreign exchange constraints are still a significant determinant of import behavior. 9/

8/ Several Latin American countries, during the 1950s and 1960s, seem to fit this case.

9/ Chile, during 1982-86, may fit this case.

3. Estimation

The present section discusses the estimation of the import models developed in this paper, using pooled cross-section time series for twenty-one developing countries, during 1970-83. It presents estimates of import behavior for four country groups (low-income countries, major exporters of manufactures, nonfuel primary commodity exporters, and oil exporters) as well as for all developing countries. 10/

Before discussing these results, two comments need to be made. First, and before estimating the pooled cross-section time series model, I tested for the eventual presence of heteroskedasticity -- assuming homoskedastic errors for each country, but allowing for heteroskedastic errors across countries -- using Bartlett's test. The results of this test suggest that for two regions (oil exporters and major exporters of manufactures) a correction for heteroskedasticity was needed. I made the appropriate correction before proceeding to estimate the model.11/ Second, I added country-intercept dummies to each equation, but assumed that the slopes were similar for all countries in each group. This model is known in the literature as a "fixed effects" model. It is also a

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10/ See the Appendix for a complete list of the countries, and World Bank (1986) for the criteria used to classify these countries.

11/ In Moran (1987) I also tested for the eventual presence of autocorrelation in the estmates for five individual countries and therefore decided to ignore it in the estimates for the pooled sample.

dynamic model, because of the inclusion of a lagged dependent variable. 12/

Table 1 presents the pooled cross-section time series results of the general import models and the two special cases, the Hemphill and benchmark models. Equations 1, 5, 9, and 13 present the results of the general model with exogenous prices, for each of the four country groups. Equation 17 presents the results for all developing countries. All the parameters have the expected signs, and the fit of the model is very good -- with adjusted R^2s varying between 0.96 and 1.00. Note that the coefficient associated with the variable measuring foreign exchange receipts (b_1) is quite significant -- and higher for low-income countries than for the other country groups. Relative prices and domestic income also play an important role in these equations, but their significance -- measured by the corresponding "t" values -- is generally smaller than the significance of foreign exchange receipts and international reserves.

The impact/short run income elasticity estimates oscillate around 0.2, with two out of five estimates being statistically significant at the one percent level, and two other estimates significant at the 5 and 10 percent level (one tailed test), respectively. The short run price elasticity estimates oscillate around -0.1, and they are significant in

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12/ Note that standard estimation techniques applied to a dynamic fixed effects model will lead to consistent estimates only if the number of time periods, T, is large (i.e. $T \to \infty$), but will remain biased if T is fixed and the number of individuals (countries), n, increases without bound (i.e. $n \to \infty$). See Nickell (1981) for a discussion of this issue. Alternative estimation procedures which are consistent when either n or T are large have been proposed in the literature (see Anderson and Hsiao 1982) but the advantages of these techniques -- in terms of reduced mean square errors -- for relatively small samples have not yet been investigated.

Table 1: General Import Model, Hemphill Model, and Benchmark Model: Pooled Cross-Section Time Series Results

$$\ln m_{it}^{GNFS} = b_0 + b_1 \ln f_{it} + b_2\, m\, r_{it-1} + b_3 \ln m_{it-1}^{GNFS} + b_4 \ln (PM/P)_{it} + b_5 \ln y_{it} + \textstyle\sum_i c_{0i} D_{it}$$

	Eq #	b_0	b_1	b_2	b_3	b_4	b_5	$\bar{R}^2$ (F)	SSR	DF
Low Income Countries	1	-0.64	0.62	0.05	0.25	-0.03	0.17	0.992	0.3617	55
		(-0.93)	(8.21)	(2.24)	(3.43)	(-0.43)	(1.63)	(891.4)		
	2	0.13	0.68	0.03	0.29	-	-	0.992	0.3877	57
		(0.27)	(9.71)	(1.37)	(4.01)			(1107.6)		
	3	0.52	-	-	0.66	-0.08	0.24	0.976	1.1421	57
		(0.45)			(5.96)	(-0.78)	(1.58)	(370.6)		
	4	-3.25	-	-	0.49	-0.64	0.86	0.962	1.7957	57
		(-1.05)			(2.62)	(-1.50)	(1.75)	(234.2)		
Major Exporters of Manufactures	5(*)	0.00	0.31	0.08	0.39	-0.08	0.21	1.000	11.2720	67
		(0.00)	(7.73)	(4.52)	(6.05)	(-1.44)	(3.02)	($>10^5$)		
	6(*)	1.07	0.52	0.31	0.07	-	-	1.000	13.0094	69
		(2.01)	(9.70)	(7.94)	(3.97)			($>10^5$)		
	7(*)	0.62	-	-	0.63	-0.22	0.27	1.000	28.8034	69
		(0.60)			(6.62)	(-2.61)	(2.47)	($>10^5$)		
	8(*)	-9.88	-	-	0.44	-1.41	1.39	1.000	115.6520	69
		(-2.06)			(2.12)	(-2.72)	(2.73)	($>10^5$)		
Non Fuel Primary Commodity Exporters	9	-1.00	0.47	0.04	0.31	-0.06	0.28	0.961	0.3176	55
		(-1.76)	(8.58)	(2.44)	(3.97)	(-1.14)	(2.34)	(177.3)		
	10	-0.01	0.53	0.03	0.46	-	-	0.959	0.3493	57
		(-0.03)	(10.31)	(2.03)	(8.82)			(214.1)		
	11	-1.18	-	-	0.39	-0.22	0.68	0.893	0.9069	57
		(-1.25)			(3.07)	(-2.63)	(3.79)	(77.4)		
	12	-7.81	-	-	-0.52	-1.76	2.33	0.538	6.4982	57
		(-2.00)			(-0.98)	(-2.42)	(2.64)	(11.6)		

Table 1: General Import Model, Hemphill Model, and Benchmark Model: Pooled Cross-Section Time Series Results

(continued)

$$\ln m_{it}^{GNFS} = b_0 + b_1 \ln f_{it} + b_2 m\, r_{it-1} + b_3 \ln m_{it-1}^{GNFS} + b_4 \ln (RM/P)_{it} + b_5 \ln y_{it} + \sum_i c_{0i} D_{it}$$

	Eq #	b_0	b_1	b_2	b_3	b_4	b_5	$\bar{R}^2$ (F)	SSR	DF
Oil Exporters	13(*)	-1.06 (-1.19)	0.51 (6.76)	0.11 (3.96)	0.28 (4.85)	-0.23 (-2.85)	0.20 (1.28)	1.000 (>10^5)	4.3169	5[illegible]
	14(*)	-0.29 (-0.71)	0.59 (9.54)	0.13 (4.32)	0.33 (6.64)	-	-	1.000 (>10^5)	5.0612	5[illegible]
	15(*)	-4.79 (-4.00)	-	-	0.27 (3.06)	-0.64 (-6.52)	1.11 (6.67)	1.000 (>10^5)	10.4004	5[illegible]
	16(*)	-8.80 (-4.41)	-	-	-0.10 (-0.62)	-1.41 (-5.90)	1.83 (6.11)	1.000 (>10^5)	21.4318	5[illegible]
All Developing Countries	17(*)	-0.89 (-2.43)	0.45 (16.28)	0.05 (5.70)	0.34 (9.78)	-0.06 (-1.80)	0.24 (5.23)	1.000 (>10^5)	41.4590	2[illegible]
	18(*)	0.42 (1.51)	0.47 (16.91)	0.04 (4.25)	0.45 (14.73)	-	-	1.000 (>10^5)	47.1690	2[illegible]
	19(*)	0.18 (0.31)	-	-	0.56 (11.23)	-0.23 (-4.96)	0.37 (5.50)	1.000 (>10^5)	102.3420	2[illegible]
	20(*)	-12.48 (-3.98)	-	-	-0.09 (-0.48)	-2.01 (-4.93)	2.18 (5.03)	0.999 (>10^5)	703.1960	2[illegible]

(*) indicates that the corresponding regression has been corrected for heteroskedasticity.
Method of estimation: Ordinary Least Squares (equations # 1-3, 5-7, 9-11, 13-15, 17-19);
Two Stage Least Squares (equations 4, 8, 12, 16, 20).
Period of estimation: 1970-83.

"t" values in parenthesis. SSR is the sum of squared residuals, and DF indicates degrees of freedom.
D_{it} is a country dummy.

only three out of five cases (with one estimate being significant at the one percent level, and the other two at the 5 and 10 percent level, respectively). Long run elasticities are somewhat higher in absolute value: income elasticities range between 0.2 and 0.4, and price elasticities range between -0.3 and -0.1.

The equations following the results for the general model (equations 2 and 3 for low-income countries) present the estimates for the two special cases, the Hemphill and benchmark models. These results again seem to fit the data quite well; all the coefficients have the expected signs and they are usually statistically significant (at the one percent level). Estimates of the foreign exchange and reserve elasticities (b_1 and b_2) in the Hemphill model oscillate around 0.5-0.6 and 0.1, respectively. They are generally higher than the corresponding elasticities in the general import model, but not by much. For example, estimates of b_1 and b_2 are 0.59 and 0.13 for oil exporters in the Hemphill model, compared with estimates of 0.51 and 0.11 in the general model. By contrast, price and income elasticities (b_4 and b_5) in the benchmark model are generally much higher than the corresponding elasticities in the general import model. For example, estimates of b_4 and b_5 are -0.64 and 1.11 for oil exporters in the benchmark model, compared to estimates of -0.23 and 0.20 in the general model. The differences in the estimated coefficients in the Hemphill and benchmark models, when compared to the corresponding parameters in the general import model, are due to the omission of relevant variables in the former models -- and the magnitude of this difference suggests the extent of the bias.

To compare explicitly the explanatory power of the general model with the two special cases, I used the conventional "F" test. This comparison shows that the general model dominates the benchmark model quite strongly -- in all cases. It also dominates the Hemphill model in two of the four country groups considered here (oil exporters and major exporters of manufactures), as well as in the estimates for all developing countries. 13/ The conclusion is that the general model should be preferred to either the Hemphill or the benchmark model. As a consequence, import equations that do not incorporate variables capturing the stringency of foreign exchange constraints (f_t, r_{t-1}), or relative prices and income (PM_t/P_t, y_t) are likely to produce biased estimates due to the omission of relevant variables. The main concern with these results, however, is that they implicitly assume that the real import price is exogenous.

The second general model presented here is formed by equations (9a) and (4). It assumes that import volumes and import prices are both endogenous. Since import prices do not appear explicitly in equation (9a), consistent estimates of this equation can be obtained by Ordinary Least Squares. These estimates are shown in equations 2, 6, 10, 14 and 18 in table 1 and were already discussed. The OLS estimates of the import demand equation (4) are, however, biased and inconsistent -- if $(PM/P)_t$ is indeed endogenous. In this case, consistent estimates of the import demand equation can be obtained through the use of an Instrumental Variable estimator, such as Two-Stage Least Squares (2SLS). These estimates are presented in the last set of regressions for each country group (in equations 4, 8, 12, 16, and 20) in table 1.

13/ The corresponding "F" values are reported in Moran (1987), Table A-4.

Observe again that the price and income elasticities of import demand changed significantly, when compared with the OLS estimates (and they are also very different from the corresponding estimates in equation (11)). For example, the new estimate of the price elasticity for oil exporters is -1.41, compared with a previous estimate of -0.64. These results suggest that the OLS bias in the price elasticity of import demand may indeed be substantial.

A formal Wu-Hausman test was used to test for the implicit bias in the OLS estimate of the price elasticity of import demand (a_1 in equation (4)). The results of this test suggest that the bias in the estimate of a_1 is substantial, except for low-income countries. The conclusion is that, under a more flexible interpretation of the import model which allows for endogenous prices (and an explicit role for foreign exchange receipts), the traditional price and income elasticity estimates of import demand obtained by OLS are likely to be subject to significant biases.

4. Summary and Conclusions

Two main import models were developed. The first model introduced two sets of explanatory variables: relative prices and domestic output; and foreign exchange receipts and international reserves. The reduced form estimates obtained from this model produced long-run foreign exchange elasticities that ranged between 0.5 and 0.8, reserve elasticities that oscillated around 0.1, price elasticities that ranged between -0.3 and -0.1, and income elasticities that ranged between 0.2 and 0.4 (table 2). This general import model contains as special cases the models normally adopted in the estimation of import equations -- the benchmark and Hemphill models. A simple F test was then used to determine whether this general model dominated each of the two submodels. The results suggest that this is generally the case. The general model dominates strongly the benchmark model in all cases. It also dominates the Hemphill model in two of the four country groups considered and in the estimates for all developing countries. Thus, the elasticities obtained from either of the two submodels are likely to be biased due to the omission of relevant variables. The main concern with these results, however, is that the real import price is assumed to be exogenous in the estimation of these models.

The second import model developed here assumes that import volumes and import prices are both endogenous, and allows explicit testing of the latter assumption. This second model includes two independent structural equations: an infinitely inelastic import-supply curve, and a normal downward-sloping demand curve. Two implications of this model were noted. First, since the supply curve is infinitely inelastic and does not respond to changes in domestic output, import volumes depend only on foreign exchange receipts and international reserves -- an implication that can certainly be relaxed (see section 5). Second, the import demand curve, which serves to determine the appropiate real import price, cannot be estimated by Ordinary Least Squares since this will produce biased and inconsistent estimates of its parameters. To test for the implicit bias in the OLS estimates (or, for the endogeneity of the real import price), the Wu-Hausman test was performed -- the test compares these estimates with those obtained with

Table 2: Long-Run Import Elasticities: Pooled Cross-Section Time Series Results*/

	Reduced Form Elasticities (General Import Model with Exogenous Prices) a/				Elasticities of Import Demand: OLS Estimates b/		2SLS Estimates	
	ϵ_f^{LT}	ϵ_r^{LT}	ϵ_p^{LT}	ϵ_y^{LT}	ϵ_p^{LT}	ϵ_y^{LT}	ϵ_p^{LT}	ϵ_y^{LT}
Low Income Countries	0.83	0.07	-0.04	0.23	-0.24	0.71	-1.26	1.69
Major Exporters of Manufactures	0.51	0.13	-0.13	0.34	-0.59	0.73	-2.52	2.48
Non Fuel Primary Commodity Exporters	0.68	0.06	-0.09	0.41	-0.36	1.11	-1.76	2.33
Oil Exporters	0.71	0.15	-0.32	0.28	-0.87	1.52	-1.41	1.83
All Developing Countries	0.68	0.08	-0.09	0.36	-0.52	0.84	-2.01	2.18

*/ The long run elasticities were calculated as $b_i/(1-b_3)$, or, as $a_i/(1-a_3)$, for i = f, r, y, p; except as noted.

a/ These elasticities were obtained from the general import model (equation (11)) estimated by OLS.

b/ These elasticites were obtained from the benchmark model (equation (4)) estimated by OLS.

c/ These elasticities were obtained from the benchmark model (equation (4)) estimated by 2SLS. The long run price and income elasticities reported for Non-Fuel Primary Commodity Exporters, Oil Exporters, and All Developing countries correspond to the estimates of a_1, and a_2, respectively (since a_3 was not statistically significant at conventional significance levels).

a consistent procedure, such as Two-Stage Least Squares. This test showed that the OLS estimates of the import demand curve are subject to significant biases, a result that again confirms the importance of foreign exchange constraints in the analysis of import behavior in LDCs. The long-run price and income elasticity estimates of import demand for each of four country groups, using OLS and 2SLS, are reported in the last four columns of Table 2. In all cases, the 2SLS estimates -- which use foreign exchange receipts and international reserves as instruments -- are much higher in absolute value than the corresponding estimates obtained with OLS.

In sum, the main conclusion obtained from the present study is that, while price and income effects are important in the analysis of import behavior in developing countries, foreign exchange constraints also play a critical role in determining imports -- as they strongly affect import volumes. Hence, import models that neglect either of these effects will yield biased estimates for developing country imports.

An important implication of this result is that policies concentrating exclusively on aggregate demand (fiscal and monetary policies) or on switching expenditures between tradables and nontradables (exchange rate policies) will have a limited effect on import volumes -- although they will certainly affect import demand. By contrast, policies that directly affect export earnings and capital inflows will likely yield a more drastic response in import volumes in LDCs. Although policies designed to affect the latter variables generally entail a significant domestic adjustment effort in the developing countries, their success -- in maintaining a smooth flow of imports -- will also depend on the continued access of LDC exports to industrial country markets, and on increased access to external capital flows, both from official and private sources.

5. Areas of Future Research

This paper has provided a stylized model of import behavior for developing countries. Actual policymaking may require, however, a more careful look at some of the key assumptions underlying this approach. I briefly mention three areas that would enrich the analysis and that may have a significant effect on the results discussed here. The first area concerns the simplicity of the dynamic structure imposed on the models presented in this study. The second area concerns the economic interpretation of both the Hemphill and the general import models. The third area concerns the exogeneity assumption of foreign exchange receipts and domestic output in the implementation of these models.

Consider first the dynamic structure. Only one lagged dependent variable was introduced here to capture adjustment costs: that is, to capture the costs of changes in the level of imports from one period to the next, due to changes in the exogenous variables. 14/ The implicit dynamic structure of this model -- known in the literature as the "partial adjustment" model -- has been criticized as being naive and sometimes misleading. Instead, Hendry and others (1986) have proposed the use of a general dynamic structure, which in the Hemphill model can be written in the following way:

14/ Hemphill also considers one lagged value of foreign exchange receipts, but the coefficient associated with this variable did not prove significant in this study.

$$\psi(L)m_t = \theta_1(L)\ f_t + \theta_2(L)r_{t-1} + \varepsilon_t$$

where $\psi(L)$, $\theta_1(L)$ and $\theta_2(L)$ are polynomials in the lag operator L, and ε_t is a random noise process. To facilitate its implementation, they have proposed a set of tests to obtain a parsimonious representation (see Hendry and others 1986, for the details of this procedure). Only then could the dynamics be fully captured, and the resulting equation used for predictive purposes.

To see how this general dynamic structure can arise naturally in import models discussed here, consider again the simple Hemphill model, equation (9):

$$(1-b_3L)\ m_t = b_0 + b_1\ f_t + b_2\ L\ r_t \tag{9}$$

If foreign exchange receipts (f_t) are decomposed into its two main components -- export receipts and net capital inflows -- and a simple linear behavioral equation is introduced for the latter variable, this gives:

$$f_t = x_t^P + k\ (x_t^{P*}, y_t^*, z_t) = x_t^P + \delta_0 + \delta_1\ x_t^{P*} + \delta_2 y_t^* + \delta_3\ z_t \tag{9.1}$$

where $\delta_1 \geq 0$, $\delta_2 \geq 0$, $\delta_3 \gtrless 0$, and

x_t^P = nominal exports deflated by the import price (or purchasing power of exports);

x_t^{P*} (y_t^*) = long run or expected value of x_t^P (y_t);

z_t = vector of other exogenous variables which are relevant for the determination of real net capital inflows (such as external economic activity, a proper set of domestic and foreign real interest rates, and the country's initial debt service ratio).

Assume, for simplicity, that expectations about x_t^P and y_t are formed adaptively, so that:

$$x_t^{P*} = [\lambda_1/(1-(1-\lambda_1)L]\ x_t^P;\ y_t^* = [\lambda_2/(1-(1-\lambda_2)L]\ y_t$$

with $0 \leq \lambda_1, \lambda_2 \leq 1$.

Substituting these two expressions into equation (9.1), and the resulting expression into equation (9), gives:

$$\psi(L)\ m_t = b_0' + \theta_1(L)\ x_t^P + \theta_2\ (L)\ y_t + \theta_3\ (L)\ z_t + \theta_4\ (L)\ r_{t-1}$$

where,

$$\begin{aligned}
\psi(L) &= (1-b_3\ L)\ (1-(1-\lambda_1)\ L)\ (1-(1-\lambda_2)\ L) \\
\theta_1(L) &= b_1\ (1-(1-\lambda_1)\ L)\ (1-(1-\lambda_2)\ L) + b_1\ \lambda_1\ \delta_1\ (1-(1-\lambda_2)\ L) \\
\theta_2(L) &= b_1\ \lambda_2\ \delta_2\ (1-(1-\lambda_1)\ L) \\
\theta_3(L) &= b_1\ \delta_3\ (1-(1-\lambda_1)\ L)\ (1-(1-\lambda_2)\ L) \\
\theta_4(L) &= b_2\ (1-(1-\lambda_1)\ L)\ (1-(1-\lambda_2)\ L).
\end{aligned}$$

In this version of the model, export receipts (x_t^P), aggregate output (y_t), international reserves (r_{t-1}), and other exogenous variables (relevant to the determination of net capital inflows) all play an independent role in determining imports, and the dynamic structure imposed on the model is indeed quite rich.

Consider now the economic rationale behind the optimization function used by Hemphill (presented in equation 5) and its generalization (equation 5'). Despite their obvious intuitive appeal -- discussed in section 2 -- these optimization functions are somewhat ad hoc. An alternative scheme with a clear economic rationale has been developed by Sachs (1981 and 1982) and Dornbusch (1983). In these studies, imports are derived from an intertemporal utility maximization problem, where expectations of future events and wealth play prominent roles. This scheme is clearly more appealing from a theoretical standpoint than the approach adopted here, but it is difficult to implement empirically.

Winters (1987) developed two empirical versions of these models (which he labeled "equilibrium" and "disequilibrium" versions) and found that the results, although promising, are not without problems, and that the empirical estimates do not appear much better than other simpler alternatives -- like the Hemphill model. More important, however, is that the intertemporal models developed by Sachs and Dornbusch assume perfect capital markets (the country can borrow unlimited amounts at a constant interest rate), an assumption that may not be appropriate for most developing countries, particularly in the 1980s. Thus, while Winters' results clearly vindicate the simple Hemphill model -- and its generalization, the general import model developed here -- there is obviously scope for improvement in the theoretical analysis of these models.

Finally, consider the exogeneity assumption about foreign exchange receipts, f_t, and total value added, y_t. In section 2 I argued that f_t can reasonably be assumed to be exogenous to the current import decision. This presumes, in particular, that external borrowing can be decomposed into an autonomous (exogenous) and an accomodating (endogenous) component. Hemphill (1974) and Winters and Yu (1985) have discussed the difficulties of this distinction. The problem may be complicated further. For example, a sudden shortfall in imports -- due to a cutback in foreign lending -- may have an effect on exports or on total value added (GDP) in the same period, as essential imported inputs are curtailed. Reserves can be used to cut this contemporaneous link, but this possibility is available only for a limited time. In short, the exogeneity of f_t and y_t should be tested rather than assumed, using tests such as those proposed by Granger and Sims (see Geweke 1986 for a recent survey of this literature). If these tests show any sign of feedback, a more general model -- where f_t, y_t, and m_t are simultaneously determined -- will have to be developed. This general model could then be estimated simultaneously, or the appropriate reduced form for imports derived and then estimated.

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APPENDIX
The Data

1. The data in this study can be defined formally as follows:

m_t^{GNFS} = Imports of goods and nonfactor services in constant dollars, obtained from the World Bank's Balance of Payments database, deflated by PM_t. 1/

PM_t = Merchandise import deflator in U.S.$, calculated by the World Bank (based on disaggregated import data at the country level). 2/

P_t = GDP deflator in U.S.$, obtained from World Bank's National Accounts database.

y_t = GDP at market prices in constant dollars, obtained from the World Bank's National Accounts database.

r_t = End-year stock of international reserves, obtained from the World Bank's Balance of Payments database, deflated by PM_t.

f_t = Foreign exchange receipts = exports of goods and nonfactor services + net factor income + net transfers + capital inflows (including direct

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1/ Note that there is no deflator for imports of GNFS at the country level derived with a comparable methodology (the implicit national accounts deflator will not be appropriate for this purpose). This explains why I used PM_t as the appropriate deflator.

2/ See C. Moran and J. G. Park, Merchandise Trade Deflators for Developing Countries, World Bank, EPD, Division Working Paper No. 1986-7 (June 1986) for a discussion of the method used to obtain the trade deflators.

private investment, long and short term loans, plus errors and omissions), obtained from the World Bank's Balance of Payments database, deflated by PM_t. 3/

2. Country Classification: The countries chosen in this study were taken to be representative of each of the main groups distinguished in the World Bank's 1986 World Development Report:

i) Low Income Countries: India, Pakistan, Kenya, Sudan and Senegal.

ii) Major Exporters of Manufactures: Korea, Argentina, Brazil, Portugal, Thailand and Yugoslavia.

iii) Non-Fuel Primary Commodity Exporters (= Other Oil Importers): Colombia, Chile, Morocco, Turkey, Cote D'Ivoire.

iv) Oil Exporters: Mexico, Indonesia, Nigeria, Peru and Algeria.

3/ I also used a narrower definition of foreign exchange receipts which excluded short-term borrowing. The results obtained with the broader definition, however, were consistently better.

	Title	Author	Date
WPS1	Imports Under a Foreign Exchange Constraint	Cristian Moran	March 1988
WPS2	Issues in Adjustment Lending	Vinod Thomas	March 1988
WPS3	CGE Models for the Analysis of Trade Policy in Developing Countries in Developing Countries	Jaime de Melo	March 1988

4/6/7/8.

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